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BUREAU OF ENTOMOLOGY AND PLANT QUARANTINE

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TITLE

HELICOPTER SPRAYING WITH DDT TO CONTROL THE WHITE-PINE WEEVIL IN JACK PINE PLANTATIONS

By

D. M. Benjamin and C. B. Eaton

Forest Insect Laboratory
Milwaukee 3, Wisconsin

April 24, 1951

SUBJECT—

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File No. 342.4
Noted by

Forest Insect Laboratory
628 E. Michigan Street
Milwaukee 2, Wisconsin
November 8, 1951

To: R. L. Furniss, Entomologist in Charge, Portland Laboratory

From: Charles B. Eaton, Entomologist in Charge, Milwaukee Laboratory

Subject: Report - "Helicopter Spraying with DDT to Control the White-Pine Weevil in Jack Pine Plantations" by D. M. Benjamin and C. B. Eaton

We are pleased to be able to furnish you with a copy of subject report for your reference and files, as requested in your memorandum of October 29th.

Charles B. Eaton

Enclosure (1)

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Entomology and Plant Quarantine
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FOREST INSECT LABORATORY,
PORTLAND, OREGON

Ken —
This is the report you requested.
R.L.F.

HELICOPTER SPRAYING WITH DDT TO CONTROL THE WHITE-PINE WEEVIL IN JACK PINE PLANTATIONS

D. M. Benjamin and C. B. Eaton

INTRODUCTION

The white-pine weevil, Pissodes strobi (Peck), has long been one of the most important insects attacking young white pine in eastern North America. Destruction of the terminal leader by the weevil generally causes the permanent deformation of the tree. When a series of attacks continue over several years, forked, multiple leader trees result which are of low commercial value. In addition to attacking white pine, the weevil also injures several species of native and exotic soft and hard pines, spruce, and Douglas-fir.

Early attempts to control the white-pine weevil with insecticides under forest conditions were generally discouraging. Not only were the results often erratic, but the cost was so high as to make the project unfeasible. With the advent of low cost, concentrated, insecticides and improved spraying equipment a renewed interest has been shown in the possibility of combatting this insect. The New Haven, Connecticut Forest Insect Laboratory has taken the lead in testing sprays to control the white-pine weevil, and in recent years has developed both techniques and insecticide formulations which show much promise. Considerable success has been achieved with concentrated lead arsenate sprays applied with ground equipment to control the weevil in white pine plantations (Crosby, 1950). Other unpublished reports by the New Haven Station show that good control was also obtained when oil solutions of DDT were applied by helicopter during the adult weevil feeding period in early spring.

In 1949 heavy infestations of the white-pine weevil occurred in jack pine plantations on the Manistee National Forest in the north central section of the lower peninsula of Michigan. Part of the infested plantings were situated in a discontinuous series of fourteen 40-acre blocks interspersed with hardwood or open areas. The location of these blocks was such that a number of separate treatment units could be established, each isolated by a non-infested buffer strip. These circumstances provided an opportunity to test insecticide concentrations and the helicopter method of application effective in the northeast, on a comparatively large scale and under midwestern conditions. It was recognized at the outset of the study that the economic value of jack pine at the present time is comparatively low, and that for this particular species the cost of controlling the white-pine weevil by applying insecticides, especially by helicopter, is quite likely to be in excess of the value to be saved even if the method was entirely successful. However, it was not the intent of the study to test the value of aerial sprays in protecting jack pine, but rather to evaluate their use in controlling the weevil. If successful, these sprays could be of use in protecting stands of more valuable species

such as white pine, where the cost of the treatment would be most likely to be commensurate with the value involved.

The work covered by this report was carried on in cooperation with the Lower Michigan National Forest, U. S. Forest Service. The study was planned and the results evaluated by the authors. R. L. Gallun and L. V. Crapp assisted in the pre-treatment and post-treatment damage surveys. Spray materials were furnished by the Lower Michigan National Forest, and Ranger J. E. Stephenson and assistants of the Cadillac District provided considerable help in executing the spraying program. Helicopter spraying services were furnished on contract by Lewis College of Science and Technology, Lockport, Illinois.

SPRAY PLOTS

The spray plots used in this study were located in jack pine plantations on the Cadillac Ranger District approximately 7 miles west of Cadillac, Michigan. Their location in relation to each other is shown on the accompanying map (Figure 1). The plantations were established in 1938 on abandoned sandblown farm land. Good survival has resulted in fully stocked stands having an average spacing between trees of 6 feet, and an average height, at the time of spraying, between 12 and 15 feet. No overstory of hardwoods was present to interfere with spray descent.

SPRAYING EQUIPMENT

A Bell helicopter (Model 47-B-1), furnished by the contractor, was used to apply the spray. This helicopter (Figure 2) was fitted with standard spraying equipment supplied by the manufacturer. The nozzles on the spray boom were 1AL Spraying Systems Company nozzles attached to 1/4 A BAL check valves. The flow rate of the spraying equipment was checked in calibration tests on the ground and in the air. It was not found that the discharge rate for the nozzles differed appreciably from the 0.189 gallon per minute rate (per nozzle) determined at Beltsville, Md. in tests with similar equipment in 1948. Spray deposit and distribution patterns were not determined. Since the helicopter was fitted with only 60, instead of 79 nozzles for which outlets are provided on the spray boom, it was necessary to use a narrower swath width for the higher dosages than would have been necessary if the full number of nozzles had been available.

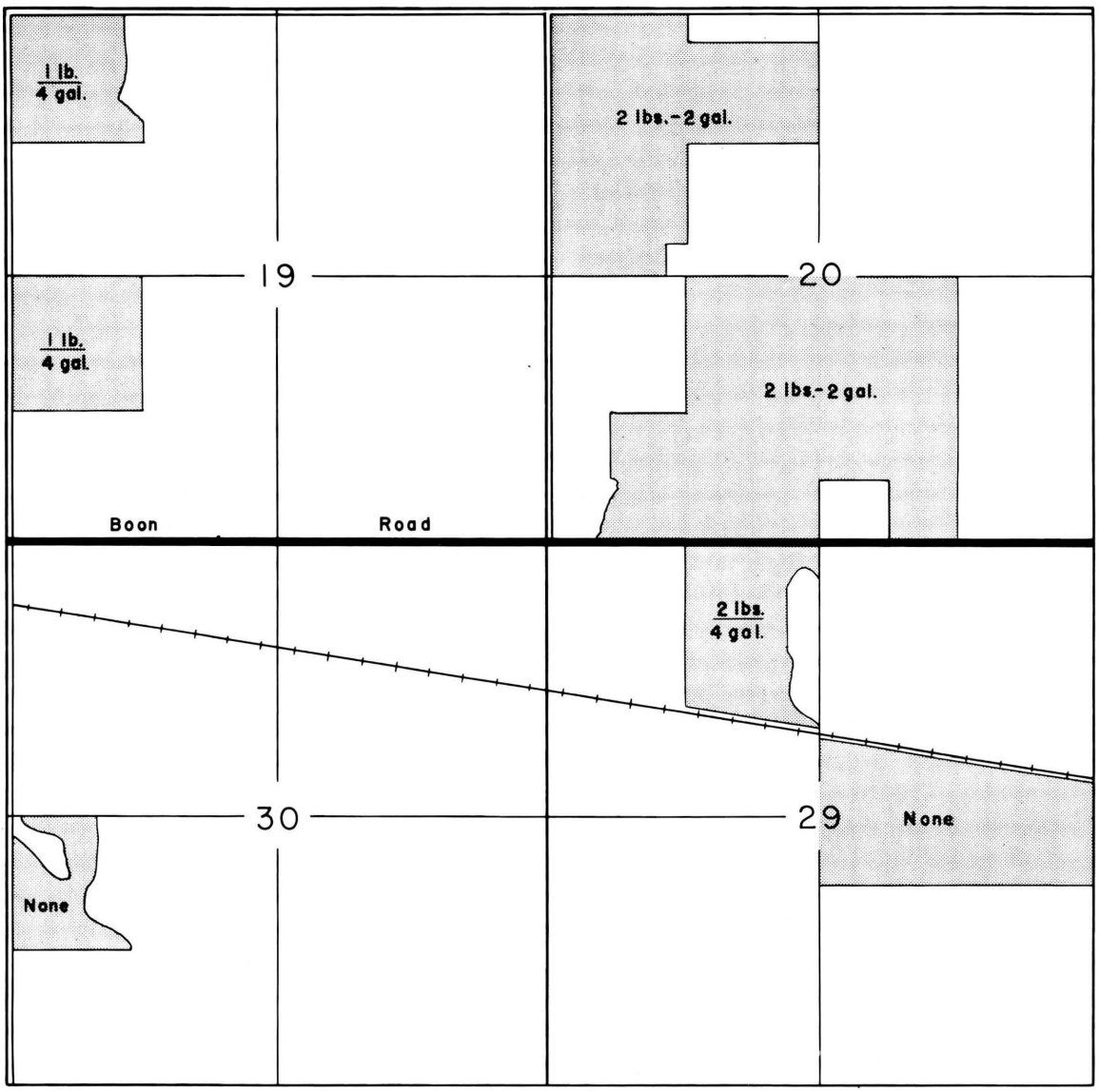
INSECTICIDE AND APPLICATION RATES

For the tests reported herein, DDT oil solutions were used at three rates of application per acre, as follows: 1 pound in 4 gallons, 2 pounds in 2 gallons, and 2 pounds in 4 gallons. The greater part of the area included in the spray plots was treated at the 2 pound in 2 gallons per acre rate. The decision to limit the formulations tested to DDT oil solutions, and to concentrate largely on the 2 gallon dosage

Figure 1

WHITE PINE WEEVIL
HELICOPTER SPRAY TEST PLOTS
1950

MANISTEE NATIONAL FOREST
CADILLAC RANGER DISTRICT
T. 22 N. R. 10 W.



B.E.&P.Q. 11-15-50

Figure 2. Helicopter at loading point taking on 50 gallons of spray. Open fields adjacent to the spray plots were satisfactory as bases for loading operations.

Figure 3. Jack pine plantation being sprayed by helicopter with DDT oil solution to control the white-pine weevil.

was based primarily on the results of experiments by the New Haven Station, previously referred to.

The insecticide was mixed at a rate of 1 pound of DDT to 1.2 quarts of auxiliary solvent made up to required volume with No. 2 fuel oil. The mixing was done at the Chittenden Nursery by U. S. Forest Service personnel. Some difficulty was experienced, especially with the 2 pound dosage, in getting the DDT into solution. This was probably due to the low temperature of the solvents. The finished spray was placed in drums and trucked to temporary landing fields adjacent to the spray plots. Filling of the helicopter spray tanks was accomplished with a hand-operated transfer pump. The following tabulation shows the quantity of spray ingredients and total volume of spray prepared for each dosage. The overrun allowance was 2.5 percent of the total spray volume required for the acreage treated.

Dosage per Acre (pounds - gallons)	Unit Quantities: DDT (pounds)	Solvent (quarts)	Fuel Oil (quarts)	Finished Spray (gallons)	Total Plot Area (acres)	Total Volume Finished Spray (gallons)
1 - 4	1	1.2	14.5	4	80	328
2 - 2	2	2.4	5.0	2	300	615
2 - 4	2	2.4	13.0	4	40	164

For the dosages tested, two rates of application of the spray liquid were required, i. e. 2 gallons per acre and 4 gallons per acre. The maximum rate of discharge with the spraying equipment furnished by the contractor was 11.3 gallons per minute. The operating speed for the helicopter was arbitrarily set at 25 miles per hour for all treatments. Thus the maximum swath width that could be covered at the 4 gallon rate was less than 1 chain. For the 2 gallon rate, a swath width of 1 chain was used and the required flow rate obtained by reducing the number of nozzles. Pertinent data concerning flow rate, number of nozzles, and swath width for each application rate are as follows:

Spray Volume (gallons)	Flow Rate (gallons per minute)	Number of Nozzles	Swath Width (feet)
2	6.6	35	66
4	11.3	60	56

TIMING OF SPRAY APPLICATION

The timing of insecticidal control measures directed against the white pine weevil is a critical consideration. In the studies reported

herein, spraying was timed to begin shortly after the bulk of the adult weevils had emerged from hibernation and had begun to feed on the expanding pine leaders. Phenological observations on the spray plots indicated that at the time the weevils began to appear, jack pine buds were showing signs of breaking dormancy and were between 1/2 and 3/4 inches long. Development of other woody species in the vicinity was at the following stages:

Black Cherry, *Prunus serotina* Ehrh.	Buds expanding, 3/8 to 1/2 inches long.
Pin Cherry, *Prunus pennsylvanica* L.f.	Buds opening, leaf buds expanding with small leaves showing, flower buds not yet open.
Hard Maple, *Acer saccharum* Marsh.	Buds expanding, 1/4 to 3/8 inches long.

INSECTICIDAL APPLICATION

The experimental areas were treated on May 12 and 13. During this period reasonably good flying conditions prevailed, although wind velocities were somewhat higher than was desirable. The helicopter was flown at 25 miles per hour, and at a height of about 15 feet above the average level of the tops of the trees (Figure 3). A balloon marker was used along one end of each plot to guide the pilot in spacing the swaths. The plantations were clearly enough delineated from the air so that no corner markers were needed, and since the helicopter operated from fields adjacent to the plots it was a simple matter to make adjustments in flight procedures as the spraying progressed. All spray plots were flown once.

On May 12 clear skies prevailed with southwest winds ranging between 5 and 9 miles per hour. At 5:30 a.m., when spraying began, the air temperature was 41° F. and the relative humidity 82 percent; when spraying terminated at 8:40 a.m. the temperature was 57° F. and the humidity 55 percent. A thunderstorm with light precipitation occurred early in the evening of May 12. On the following day a heavy overcast and mist was present during the early hours. During the period of spraying (6:00 a.m. to 12:00 m.) air temperatures were between 45° F. and 48° F. During the latter part of the morning the wind was northwest, between 5 and 11 miles per hour. Precipitation totaling 0.03 inches fell during the evening of May 14.

A total of 400 out of the 420 acres scheduled for treatment were sprayed. Failure to complete the last 20 acres was due to a breakdown in the spray distributing equipment on the helicopter with the last load of spray. The untreated acreage was a part of that scheduled for the 2 pound in 2 gallons per acre dosage. Except for this difficulty, which fortunately occurred at the very end of operations, the performance of the spraying equipment and the work of the pilot were highly

satisfactory. Carrying nearly 50 gallons per load, the helicopter distributed nearly 1,070 gallons of spray in slightly more than 9 hours of operating time. This record could have been bettered considerably had a power transfer pump been available for loading the spray, and had aviation gasoline been on hand at the landing fields to refuel the ship.

RESULTS

No attempt was made to determine the quantity of insecticide reaching the plots nor to determine the adult weevil mortality immediately following spraying. Instead, the amount of weevil damage, that is, the number of weeviled leaders observed in 1950, was compared to the number of leaders weeviled in 1949 on the sprayed areas and on the nearby non-sprayed areas. From these counts the degree of control due to the treatments was computed. The pre-treatment counts were made in August, 1949, when a 1 percent cruise was made of the 520 acres of plantations used in the tests. In this cruise, twenty 1/50-acre plots per 40 acres of plantation were established, on which 3,408 trees were examined. The post-treatment counts were made in September, 1950, after completion of this year's weeviling. Examinations were made of 5,654 trees, following in general the system already outlined. The number of trees examined and the percent weeviled on the plots in each sampling unit (40 acres), both before and after spraying, are shown in Table 1.

In analyzing the infestation data, all plantations receiving the same treatment were grouped and considered as a single unit (Table 2). For each treatment the percent of the trees weeviled in 1949 and 1950 was computed. The difference, due to all causes, between the amount of weeviling in the two years was calculated as a percentage of the amount occurring in 1949. The percent reduction in weeviling attributable to the insecticide on the sprayed plots was calculated after deducting the amount due to natural causes as indicated by the data for the unsprayed plots. It was assumed in this calculation that the 93.8 percent reduction in weeviling caused by natural factors on the non-treated plots was approximated on all treated plots within the experimental area.

The data presented in Table 2 show that the gross reduction in weevil damage in plantations sprayed with 1 pound in 4 gallons per acre was 78.3 percent; that in the plantations sprayed with 2 pounds in 2 gallons per acre was 99.0 percent; while the gross reduction for those plantations treated with 2 pounds in 4 gallons per acre was 98.6 percent. For the two latter dosages the spraying was apparently effective; the reduction in weeviling, due to the insecticide alone being 84.1 and 77.1 percent respectively of the amount not due to natural causes. The 1 pound in 4 gallon dosage, however, was not only ineffective in these tests but apparently had a detrimental effect on natural factors affecting the weevil. A reduction in weeviling of only 78.3 percent occurred where this treatment was used. This represents an increase rather than a decrease in weevil damage on the sprayed plots amounting to 251.0 percent of that which would have occurred had natural factors alone been operating. Negative control may be said to have occurred.

TABLE 1. Number of Jack Pine Trees Examined and Percent Weevilled in Each Sampling Unit Before and After Spraying. Cadillac District, Manistee National Forest.

Dosage per Acre				Before Treatment (1949)		After Treatment (1950)	
DDT (lbs.)	Solution (gals.)	Sampling Unit	Area (acres)	No. Trees Examined	Percent Weevilled	No. Trees Examined	Percent Weevilled
0	0	NWSW S.30	30	331	68.9	264	11.4
		S 1/2 S 1/2 NE S.29	30	176	61.4	418	2.2
		N 1/2 N 1/2 SE S.29	40	198	54.6	440	1.1
1	4	NWNW S.19	40	347	53.0	440	15.2
		NWSW S.19	40	579	47.7	440	6.4
2	2	W 1/2 W 1/2 NW S.20	40	220	63.2	440	1.1
		E 1/2 W 1/2 NW S.20	40	215	59.5	440	0.9
		NENW S.20	30	198	60.6	396	0.5
		W 1/2 E 1/2 SW S.20	40	220	59.1	440	0.5
		E 1/2 E 1/2 SW S.20	40	198	80.3	440	0.2
		W 1/2 W 1/2 SE S.20	30	154	57.1	330	0.6
		E 1/2 W 1/2 SE S.20	40	198	55.6	440	0.5
		E 1/2 SW SW S.20	20	110	43.6	220	0.5
2	4	NENW S.29	40	264	56.4	506	0.8
Total			500	3,408	57.9	5,654	-

TABLE 2. Incidence of Weevil Damage Before and After Treatment in Jack Pine Plantations Sprayed by Helicopter with DDT. Cadillac District, Manistee National Forest.

Dosage per Acre		No. of	Aggregate	Before Treatment (1949)		After Treatment (1950)		Reduction in Weevil Damage	
DDT (lbs.)	Solution (gals.)	Sampling Units	Area (acres)	No. Trees Examined	Percent Weeviled	No. Trees Examined	Percent Weeviled	Total (percent)	Spray (percent)
0	0	3	100	705	63.0 ± 3.6	1,122	3.9 ± 3.2	93.8	-
1	4	2	80	926	49.7 ± 2.6	880	10.8 ± 4.4	78.3	-251.0
2	2	8	280	1,513	60.9 ± 2.9	3,146	0.6 ± 0.1	99.0	84.1
2	4	1	40	284	56.4	506	0.8	98.6	77.1

Chi-square analysis of these data indicated significant weevil-ing reductions on the units treated with DDT at the rate of 2 pounds in 2 gallons and 2 pounds in 4 gallons of solution per acre. Because only a single 40-acre plantation was treated at the latter rate the significance of the apparent superiority of the 2 pounds in 2 gallons per acre dosage is questionable. The increase in weevilling which occurred on the plantations treated at the rate of 1 pound of DDT in 4 gallons of solution per acre was statistically significant.

DISCUSSION

The results of these tests indicate that DDT sprays applied by helicopter can be successfully used to control the white-pine weevil but they do not offer conclusive evidence. Their weakness lies in the fact that for unknown reasons a tremendous natural reduction in damage, suggestive of a catastrophic decline in the weevil population, apparently occurred in the experimental area during the period of study. It is true that for the most part the results do not refute findings of similar tests conducted in the Northeast; on the other hand neither do they offer strong support for these findings. On the basis of the Michigan work alone, it is doubtful if sprays applied by helicopter could be recommended for controlling the white-pine weevil. However, considering the excellent results in the Northeast, further trials of the method would be warranted where valuable plantations need protection from this pest.

Reasons for the apparent decline in the weevil population, as indicated by the reduction in damage on the untreated plots, are not clear, and little factual evidence exists from which to develop a reasonable explanation. Several observations in this connection may be of some interest, however. For one thing, the decline in weevil damage did not appear to be limited to the jack pine stands on the experimental area alone. The decline was general in this section, particularly in plantations comparable in age to those treated; and the absence of weevil injury in stands that during the past two years, at least, have suffered so severely as to appear "brown" by mid-summer, was conspicuous in August of 1950. It should also be noted that the spring and summer of 1950 were both cold and wet in central Michigan, as well as for the region as a whole. These conditions, which may have been detrimental to the weevil population, were highly favorable for tree growth. Finally, and perhaps of more significance than either of the two foregoing observations, is the possibility that the jack pine stands in which the tests were conducted, may have been approaching height limitations above which weevil damage is not serious. This observation is largely a matter of conjecture, since there seems to be little information of record regarding the height at which jack pine escapes weevil attack. MacAloney (1943) reports that for white pine the rate of infestation is highest when the trees are from 20 to 25 feet in height. If this is equally true for jack pine, then little importance can be attached to height as a limiting factor in the present study, since the height of the jack pine averaged from 12 to 15 feet at the time of spraying. However, it would be advisable in

further tests of this kind to select stands about half as high as those treated in 1950. This practice would help eliminate height as a factor limiting the natural infestation, and also simplify pre- and post-treatment surveys.

Quite aside from the interpretations that may be placed on aspects of this study concerned solely with control of the weevil by use of insecticides, the results strongly suggest the need for a better understanding of natural factors affecting the insect in jack pine plantations. If such sharp declines in population as were encountered in these studies can occur within the space of one year because of natural causes, it might be advantageous to determine what these causes are and whether or not they can be used in preventing weevil damage.

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